Toward Better Intraseasonal and Seasonal Prediction: Verification and Evaluation of the NOGAPS Model Forecasts

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LONG TERM GOALS

The long-term goals of this project are to improve the intraseasonal to seasonal prediction skills of the NOGAPS model, in particular, to improve the prediction of MJO and its associated teleconnection patterns.

OBJECTIVES

The project has two objectives:

i) Evaluate the intraseasonal and seasonal predictions of the NOGAPS model against reanalysis data and satellite observations, and assess the model prediction skills;

ii) Evaluate the model parameterizations in different climate regimes, identify error sources, and provide the model development team with concrete information on model deficiency and recommendations on model improvement.

APPROACH

As the first step, we will evaluate the MJO and its remote impacts in the NOGAPS model. We will use the NOGAPS analysis, NOGAPS operational forecasts, NCEP/NCAR reanalysis data (or ERA-Interim reanalysis data), and precipitation observations (such as TRMM and CMAP) and employ the MJO metrics developed by the U.S. CLIVAR MJO working group.

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i) Examination of the model mean states

1) Seasonal mean precipitation in DJF and JJA will be compared to observations
2) Global and tropical mean precipitation at different forecast leads (Day 1-Day 7) will be examined.

ii) MJO and its remote impacts in the model simulations

1) Wave-number frequency diagrams will be used to examine the MJO signals.
2) Composite analyses of the wind, moisture and precipitation fields in different phases of the MJO will be carried out to examine key features of the MJO and the associated teleconnection patterns.
3) The northward propagation over the Asian monsoon region will be examined as well.

To investigate possible error sources in the model, we will evaluate the cloud properties and structure in different climate regimes in the NOGAPS model against satellite observations. Some parameter variables have different meanings in different models and satellite retrievals. To facilitate comparison between model simulations and satellite observations, we will employ the observation simulator package developed by the Cloud Feedback Model Intercomparison Project (CFMIP), *COSP*. COSP will convert the model hydrometers (condensate and precipitation) into pseudosatellite observations. The synthesized cloud properties derived from model forecasts will be evaluated against the CloudSat/CALIPSO. This approach avoids the uncertainties from inversion models used satellite retrieval algorithms and allows models to be evaluated against satellite retrievals in a consistent way.

Currently, NOGAPS does not have prognostic cloud properties. The NOGAPS modeling team at the NRL-Monterey is designing and implementing a prognostic cloud scheme for the NOGAPS as part of their model improvement. We hope to include this package in our hindcasts.

WORK COMPLETED

This is the first year of the project. We attended *the First ONR DRI workshop on Unified Parameterization for Seasonal Predictions* in Monterey in May 2011. This workshop brought the PIs and some NRL scientists together. It provided an excellent opportunity for scientific exchanges and promoted collaboration between the PIs and the NRL scientists.

Since the workshop, we have been talking to James Ridout, Maria Flatau and Y.J. Kim at the NRL about carrying out a suite of hindcasts. The hindcasts will be performed with the latest available version of the operational model (NOGAPS or NAVGEM). The model will be initialized with the data assimilation package, and hindcasts will be carried out for 45 days, which is beyond the present operational forecast range of the NOGAPS model. This dataset will be used to evaluate the subseasonal and seasonal prediction skills of the NOGAPS model. In particular, the hindcasts will be initialized at various phases of the MJO life cycle to examine the impacts of the MJO on both predictability and prediction skills. We will also test different model resolutions and different model physics parameterizations if computational resources are available. We hope that this effort will produce a dataset that can be used by other research groups as well, and will get input from other groups before carrying out the hindcasts.

Another task in the first year of the project is to develop the diagnostic tools and evaluate the NOGAPS analysis and short-term forecasts against reanalyses and satellite observations. A new graduate student joined Wang's research group in August 2011. Under Dr. Wang and Dr. Peng's supervision, the student has implemented and tested some MJO diagnosis tools. The preliminary diagnoses of the MJO in the NOGAPS analysis data are shown below.

RESULT

The variance of 20-100 day band-pass filtered outgoing long-wave radiation (OLR) in boreal winter (Nov-Apr) and boreal summer (May-Oct) is shown in Fig. 1. Strong intraseasonal variability of OLR is present over the equatorial Indian Ocean and the equatorial West Pacific in both seasons. Over the West Pacific, large variances are confined south of the equator in boreal winter, associated with the Australian summer monsoon. In boreal summer, the variability center shifts northward to the Asian summer monsoon region, and the OLR variance is also enhanced over the Bay of Bengal and the eastern Arabian Sea.

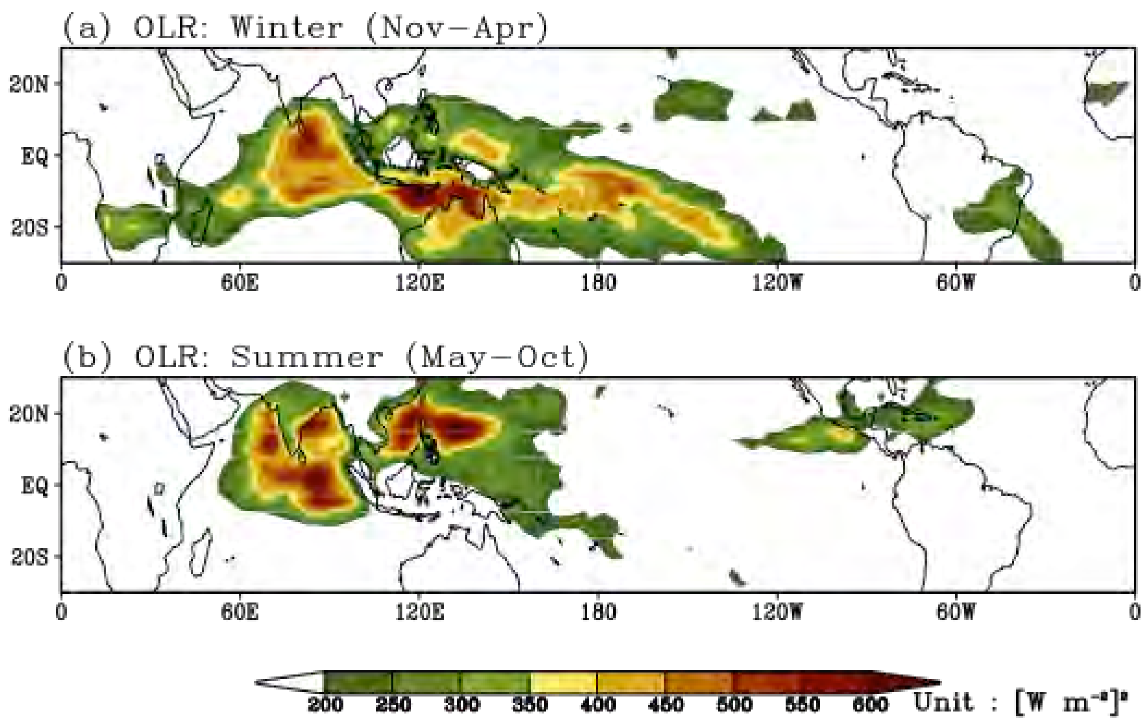

Figure 1 Variances of 20-100 day band pass filtered outgoing long-wave radiation (OLR): (a) winter; (b) summer.

The variance of band-pass filtered 850 hPa zonal wind from NCEP2 is consistent with that of OLR, showing strong variablity over the equatorial Indian Ocean and the equatorial West Pacific, but the equatorial asymmetry in the two seasons is stronger in the wind field. Besides, strong intraseasonal variability is found over the East Pacific and the North Atlantic as well, where SST is relative cold compared to the western Pacific. The 850 hPa zonal wind from the NOGAPS analyses is in good

agreement with that from NCEP2, except having slightly stronger variance over the East Pacific in both seasons.

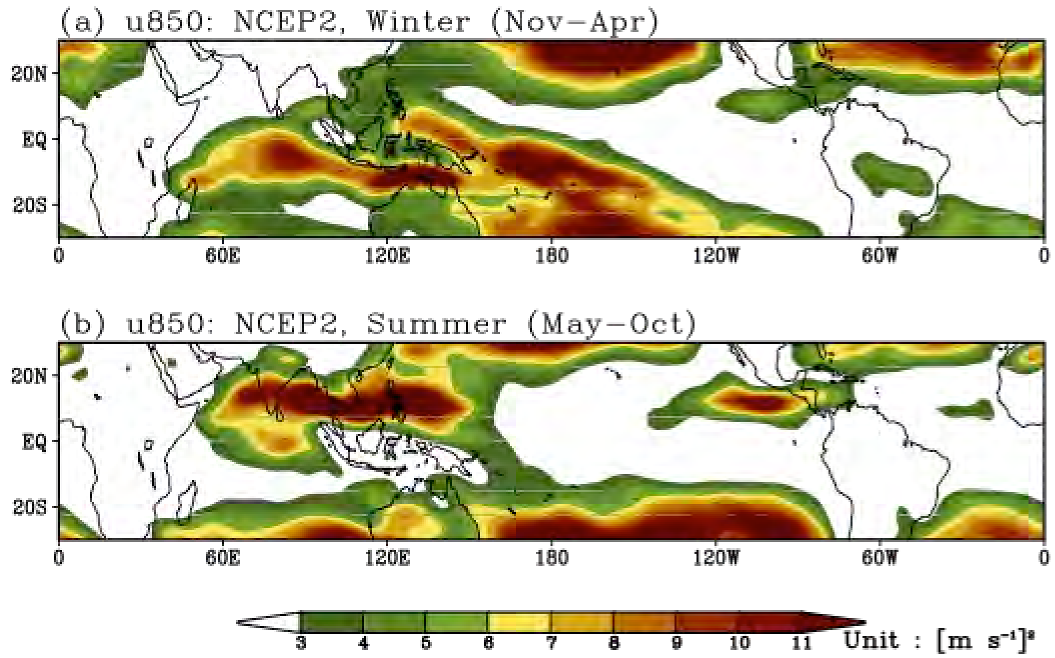

Figure 2 Same as Fig. 1 except for 850 hPa zonal wind from the NCEP2 reanalyses.

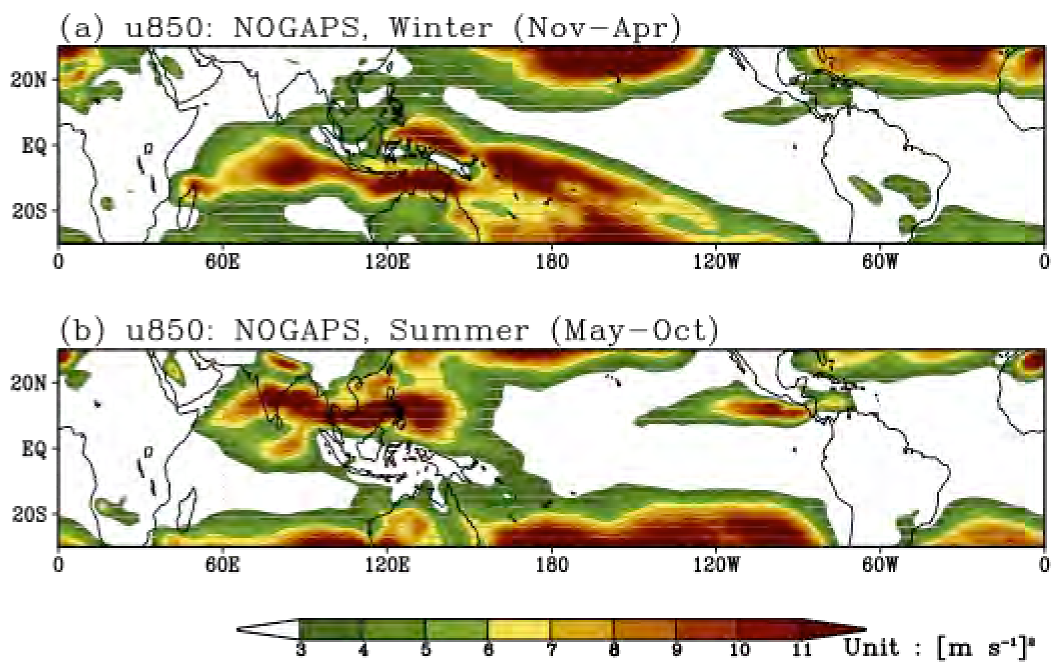

Figure 3 Same as Fig. 1 except for 850 hPa zonal wind from the NOGAPS analyses.

The wavenumber-frequency analysis is used to further examine the intraseasonal variability of 200 hPa zonal wind in NCEP2 and NOGAPS (Fig. 4 and Fig. 5). Both datasets show eastward propagating signals stronger than westward propagating signals, with maximum power spectra at global wavenumber-one and period between 40-50 days, but the power spectra derived from the NOGAPS data are weaker than those from NCEP2.

Composites are also derived for 850 hPa zonal wind and relative humidity at eight phases of the MJO. The eight MJO phases are defined based on the "All-season Real-time Multivariate MJO Index" (RMM1, RMM2) (Wheeler and Hendon 2004). The composites of U850 derived from the NOGAPS analysis are in good agreement with those derived from NCEP2, but some regional-scale differences are also discernible. The significance of the differences needs to be further tested.

The differences of relative humidity composites between the two datasets are larger than those of the dynamic fields, in particular for Phases 4, 5 (with convection center over the Maritime Continent) and Phases 1, 8 (with convection center over the western hemisphere and Africa). The implications of the differences to precipitation prediction will be further examined.

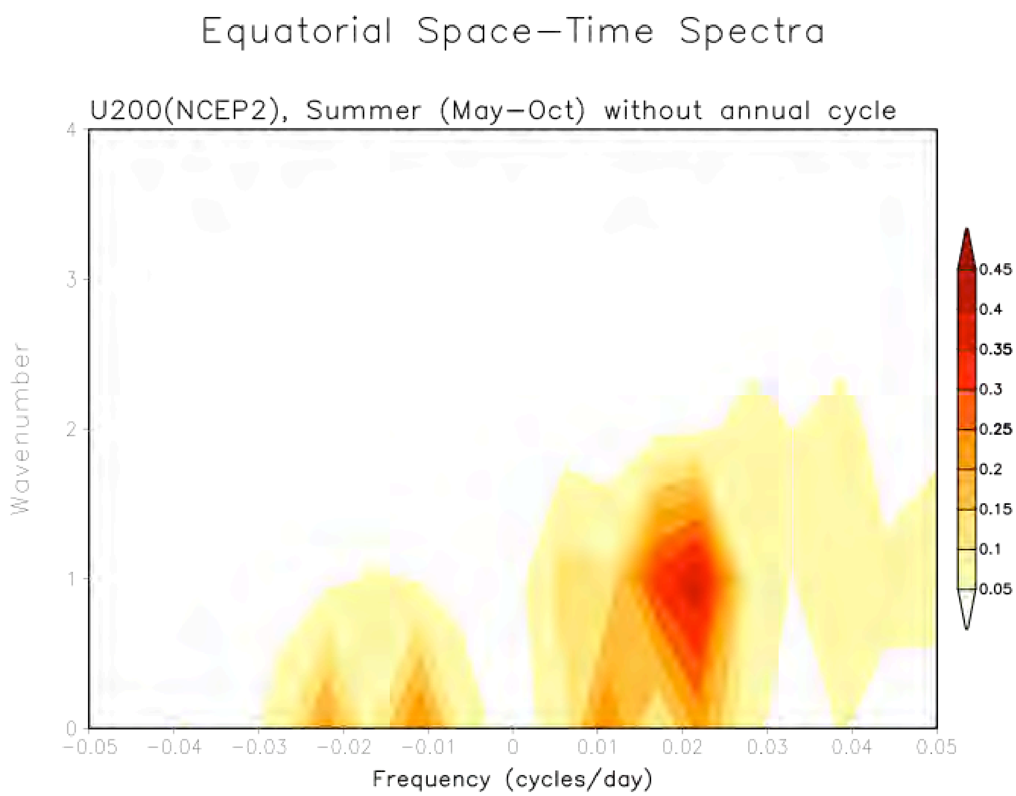

Figure 4 Wavenumber-frequency analysis of the 200 hPa zonal wind from NCEP2 in boreal summer (May-Oct).

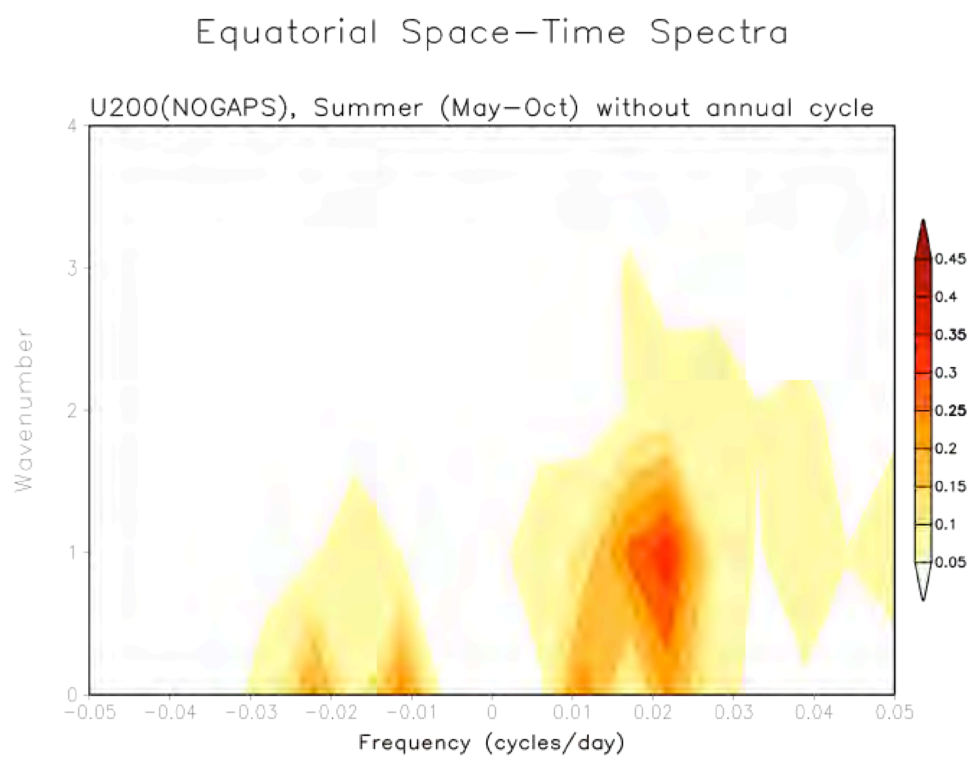

Figure 5 Same as Fig. 4, except for the 200 hPa zonal wind from the NOGAPS analyses.

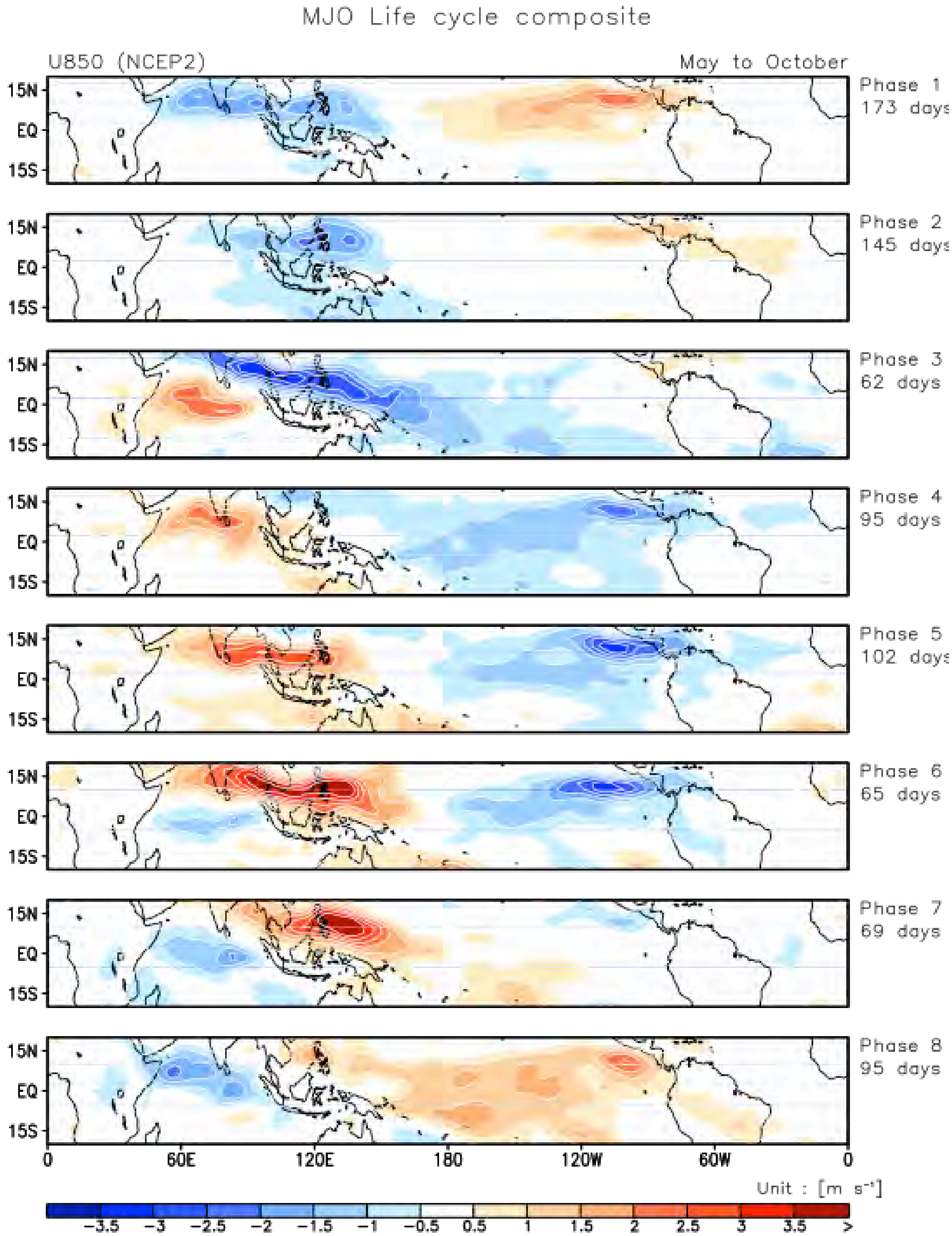

Figure 6 Composites of 850 hPa zonal wind from NCEP2 for different phases of the MJO in boreal summer.

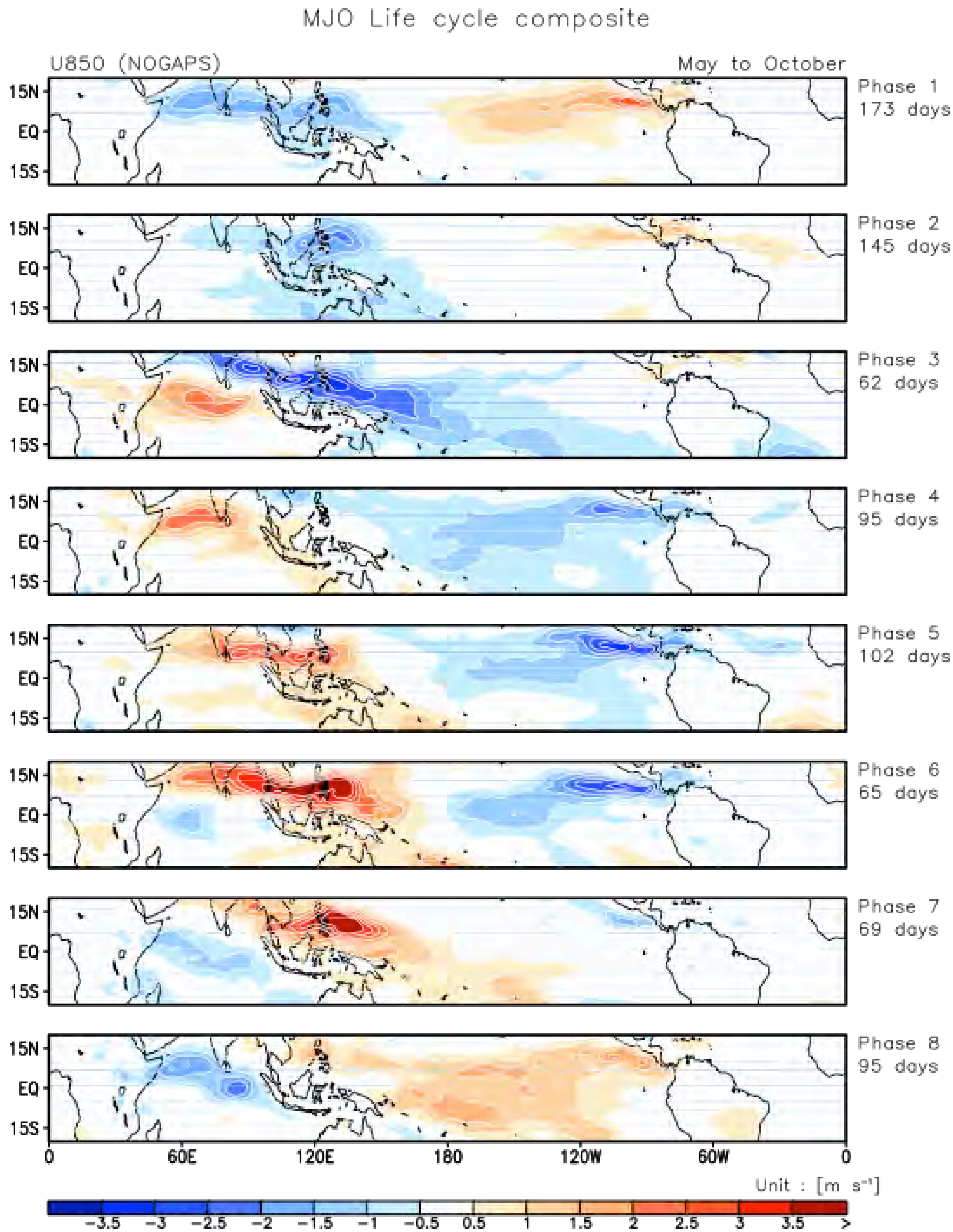

Figure 7 Same as Fig. 6 except for 850 hPa zonal wind from the NOGAPS analyses.

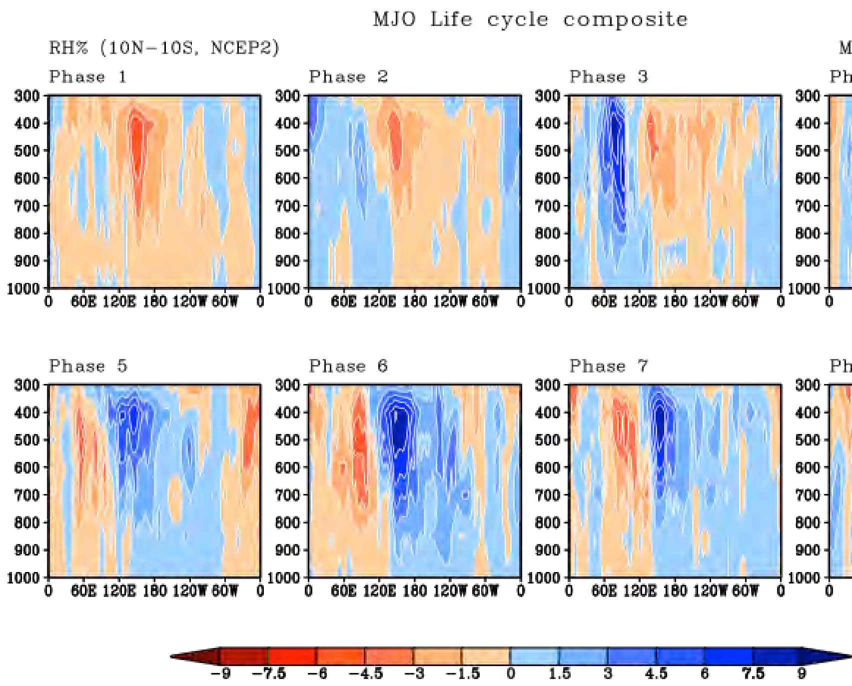

Figure 8 Longitude-height cross section of relative humidity from NCEP2 for different phases of MJO. Relative humidity is averaged between 10S-10N.

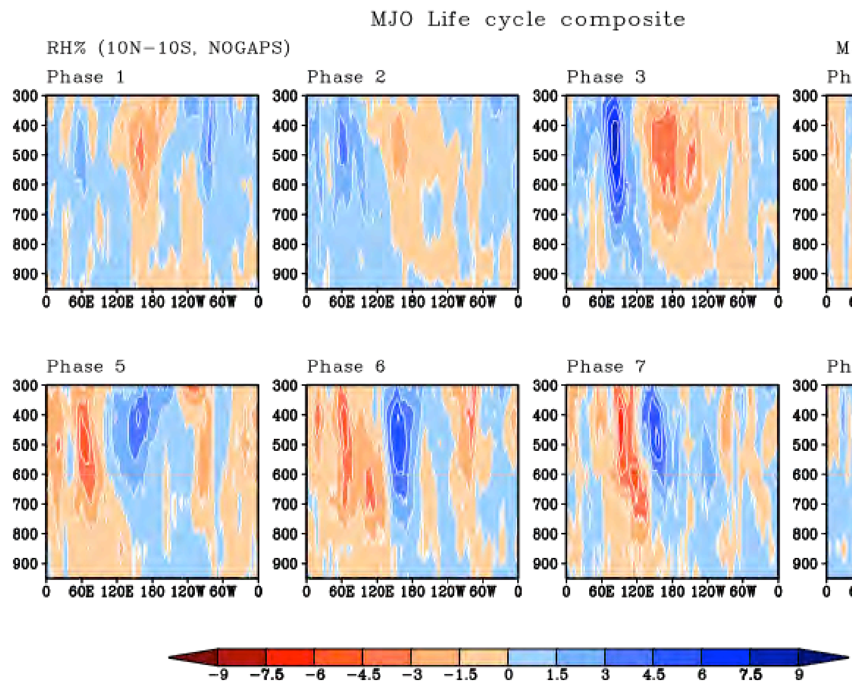

Figure 9 Same as Fig. 8 except for relative humidity from NCEP2.